## CLAIMS

What is claimed is:

1     1.     A method for correcting signals received from an earth formation using a

2           Nuclear Magnetic Resonance (NMR) tool into a borehole in said earth formation,

3           the method comprising:

4           (a)     exciting said earth formation with a first pulse sequence having a first

5                     recovery time;

6           (b)     exciting said earth formation with a plurality of additional pulse sequences

7                     having a second recovery time less than said first recovery time;

8           (c)     determining from spin echo signals resulting from said additional pulse

9                     sequences an estimate of a non-formation signal; and

10         (d)     correcting spin echo signals resulting from said first pulse sequence using

11                 said estimate and obtaining corrected spin echo signals.

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1     2.     The method of claim 1 wherein at least one of said additional pulse sequences has

2           a duration less than a duration of said first pulse sequence.

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1     3.     The method of claim 1 wherein said second recovery time corresponds to partial

2           recovery of nuclear spins in said earth formation.

3

1     4.     The method of claim 1 wherein said additional pulse sequences comprise clay

2           bound water (CBW) sequences.

3

1 5. The method of claim 1 wherein said additional pulse sequences have durations

2 less than 40 ms.

3

1 6. The method of claim 1 wherein said first pulse sequence and said additional pulse

2 sequences comprise CPMG sequences.

3

1 7. The method of claim 1 wherein said first pulse sequence and said additional pulse

2 sequences comprise modified CPMG sequence having a tip angle of a refocusing

3 pulse that is less than 180°.

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1 8. The method of claim 1 wherein said additional pulse sequences comprise pulse

2 sequences having a plurality of pairs of phase alternated pairs (PAP) of pulse

3 sequences.

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1 9. The method of claim 6 wherein said plurality of pairs of PAP sequences have a

2 specified phase relationship to each other.

3

1 10. The method of claim 8 wherein the number of said pairs of PAP sequences $nf$,

2 frequency shift between said pairs of PAP sequences $\delta f$ are related according to:

3 $$nf \cdot \delta f = \frac{m}{t}$$

4 where $m$ is any integer that is not a multiple of $nf$.

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1   11.   The method of claim 8 wherein said non-formation signal comprises a ringing

2        from a refocusing pulse.

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1   12.   The method of claim 8 wherein said non-formation signal comprises a ringing

2        from an excitation pulse.

3

1   13.   The method of claim 11 wherein estimating said ringing from said refocusing

2        pulse further comprises:

3        (i)    separately estimating a ringing from each one of said plurality of phase

4               alternated pairs;

5        (ii)   forming a vector sum of said separate estimates.

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1   14.   The method of claim 12 wherein estimating said ringing from said excitation

2        pulse further comprises:

3        (i)    separately estimating an echo signal from each one of said plurality of

4               phase alternated pairs; and

5        (ii)   forming a vector sum of said separate estimates of said echo signal.

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1   15.   The method of claim 1 further comprising processing said corrected spin echo

2        signals for determining at least one of (i) a $T_2$ distribution, (ii) total porosity, (iii)

3        bound volume irreducible, (iv) a $T_1$ distribution, (v) clay bound water, and, (vi)

4        bound water moveable.

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1    16.    The method of claim 1 further comprising conveying said NMR tool into said

2           earth formation on one of (i) a wireline, (ii) a drilling tubular, and, (iii) a

3           slickline.

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1    17.    The method of claim 1 further comprising:

2           (i)     exciting said earth formation with a  second pulse sequence having a

3                   recovery time substantially equal to said first recovery time, said second

4                   pulse sequence forming a phase alternated pair with said first pulse

5                   sequence; and

6           (ii)    determining from spin echo signals resulting from said first and second

7                   pulse sequences an additional estimate of said non-formation signal.

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1    18.    The method of claim 17 further comprising:

2           (A)     comparing said estimate and said additional estimate of said non-

3                   formation signal; and

4           (B)     using a result of said comparison as an indication of a change in said earth

5                   formation between positions of said NMR tool at excitation with said first

6                   and second pulse sequences.

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1    19.    An apparatus for  conducting logging operations in a borehole in an earth

2           formation, the apparatus comprising:

3           (a)     a magnet on  a  Nuclear Magnetic Resonance (NMR) tool for polarizing

4                   nuclear spins in a region of interest in the earth formation;

5     (b)     an antenna on the NMR tool for:

6         (A)     exciting said earth formation with a first pulse sequence

7                 having a first recovery time;

8         (B)     exciting said earth formation with a plurality of additional

9                 pulse sequences having a recovery time less than said first

10                recovery time;

11    (c)     a processor for

12         (C)     determining from spin echo signals resulting from said

13            additional pulse sequences an estimate of a non-formation signal, and

14         (D)     correcting spin echo signals resulting from said first pulse

15                sequence using said estimate and obtaining corrected spin echo

16               signals.

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1    20.     The apparatus of claim 19 wherein said additional pulse sequences comprise

2          clay bound water (CBW) sequences.

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1    21.     The apparatus of claim 19 wherein said additional pulse sequences have

2          durations less than 40 ms.

3

1    22.     The apparatus of claim 19 wherein said first pulse sequence and said additional

2          pulse sequences comprise CPMG sequences.

3

1  23. The apparatus of claim 19 wherein said first pulse sequence and said

2 additional pulse sequences comprise modified CPMG sequence having a tip angle

3 of a refocusing pulse that is less than 180°.

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1  24. The apparatus of claim 19 wherein said additional pulse sequences comprise

2 pulse sequences having a plurality of pairs of phase alternated pairs (PAP) of

3 pulse sequences.

4

1  25 The apparatus of claim 24 wherein said plurality of pairs of PAP sequences

2 have a specified phase relationship to each other.

3

1  26 The apparatus of claim 24 wherein the number of said pairs of PAP sequences

2 $nf$, frequency shift between said pairs of PAP sequences $\delta f$ are related

3 according to:

4 $$nf \cdot \delta f = \frac{m}{t}$$

5 where $m$ is any integer that is not a multiple of $nf$.

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1  27 The apparatus of claim 24 wherein said non-formation signal comprises a ringing

2 caused by a refocusing pulse.

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1  28 The apparatus of claim 24 wherein said non-formation signal comprises a ringing

2 caused by an excitation pulse.

3

1   29   The apparatus of claim 24 wherein said processor estimates said ringing caused

2       by said refocusing pulse by:

3       (i)     separately estimating a ringing from each one of said plurality of phase

4             alternated pairs;

5       (ii)     forming a vector sum of said separate estimates.

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1   30   The apparatus of claim 25 wherein said processor estimates said ringing caused

2       by said excitation pulse by:

3       (i)     separately estimating an echo signal from each one of said plurality of

4             phase alternated pairs; and

5       (ii)     forming a vector sum of said separate estimates of said echo signal.

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1   31   The apparatus of claim 21 wherein said processor further determines from said

2       corrected spin echo signals at least one of (i) a $T_2$ distribution, (ii) total porosity,

3       (iii) bound volume irreducible, (iv) bound water movable, (v) clay bound water,

4       and, (vi) a $T_1$ distribution.

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1   32.   The apparatus of claim 19 further comprising a conveyance device for

2       conveying said NMR tool into said borehole, said conveyance device selected

3       from (i) a wireline, (ii) a drilling tubular, and, (iii) a slicline

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1   33.   The apparatus of claim 15 wherein said transmitter further excites said earth

2       formation with a second pulse sequence having arecovery time substantially equal

3      to said first recovery time, said second pulse sequence forming a phase alternated

4      pair with said first pulse sequence; and wherein said processor further

5      determines from spin echo signals resulting from said first and second pulse

6      sequences an additional estimate of said non-formation signal.

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1   34.   The apparatus of claim 33 wherein said processor further:

2      (i)    compares said estimate and said additional estimate of said non-

3            formation signal; and

4      (ii)   provides an indication of a change in said earth formation between

5            positions of said NMR tool at excitation with said first and second pulse

6            sequences.

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